

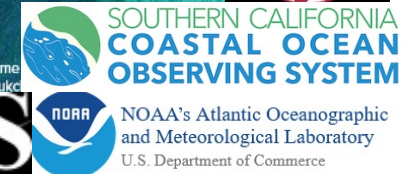
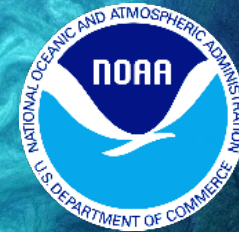
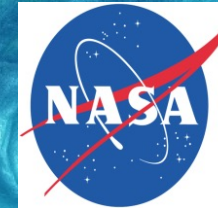
MBON remote sensing working group

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SATELLITE REMOTE SENSING AND THE MARINE BIODIVERSITY OBSERVATION NETWORK

CURRENT SCIENCE AND FUTURE STEPS

By Maria T. Kavanaugh, Tom Bell, Dylan Catlett, Megan A. Cimino, Scott C. Doney, Willem Klajbor, Monique Messié, Enrique Montes, Frank E. Muller-Karger, Daniel Otis, Jarod A. Santora, Isaac D. Schroeder, Joaquin Trinanes, and David A. Siegel



College of Earth, Ocean, and Atmospheric Sciences



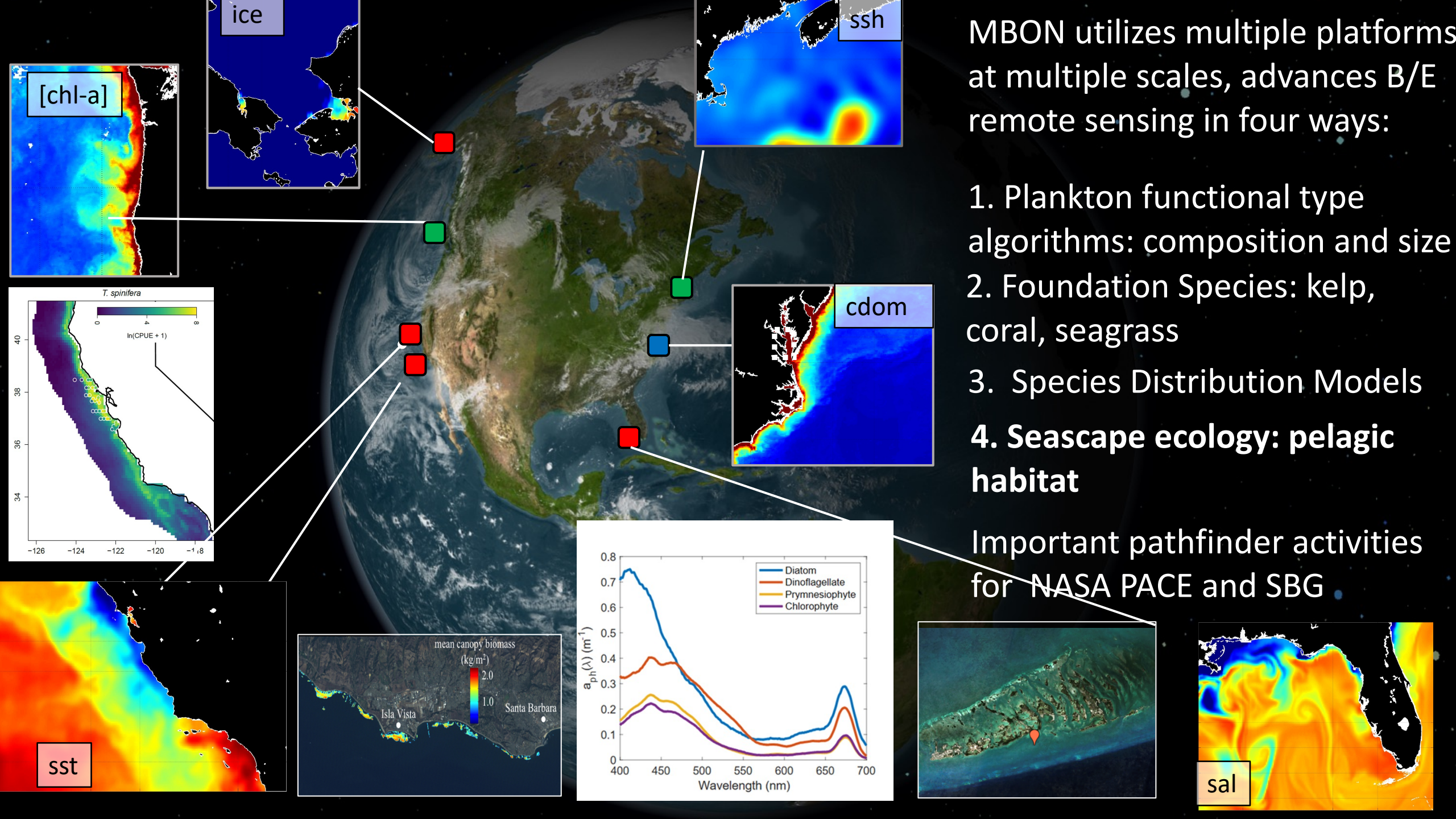
Waters off the Alaskan coast usually come plankton, visible in this image of the Chuk



MBON utilizes multiple platforms at multiple scales, advances B/E remote sensing in four ways:

1. Plankton functional type algorithms: composition and size
2. Foundation Species: kelp, coral, seagrass
3. Species Distribution Models
- 4. Seascape ecology: pelagic habitat**

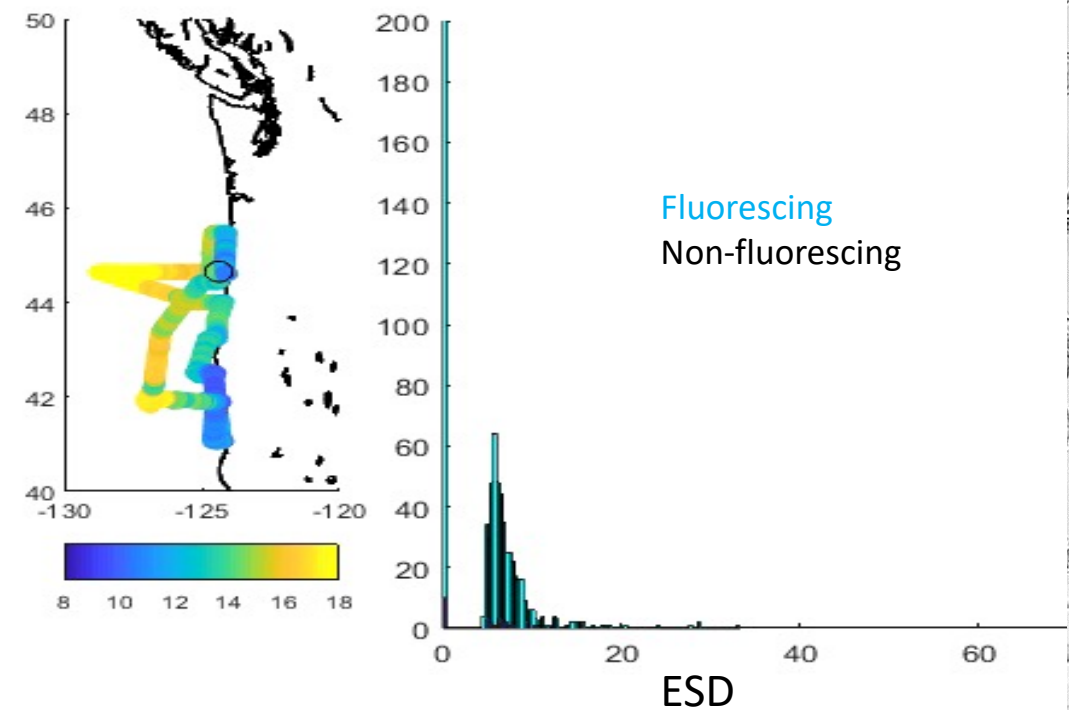
Important pathfinder activities for NASA PACE and SBG



PFT: Creating robust validation data sets for dominant groups AND size distribution across time, optically-varying water masses, and trophic structure

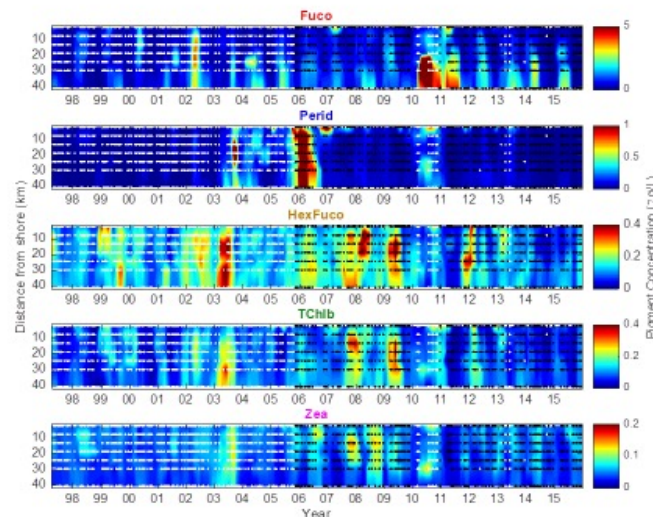
End-users: IEA, Sanctuaries, PACE, and carbon cycle science

Owners: Siegel, Montes, Kavanaugh

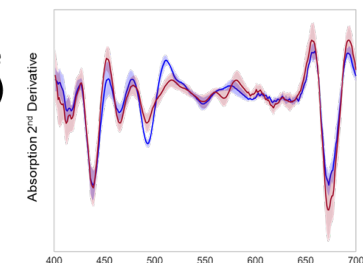
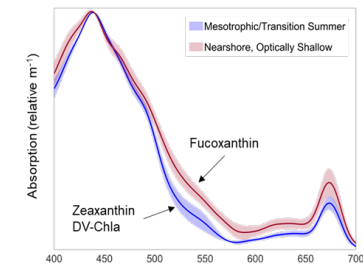
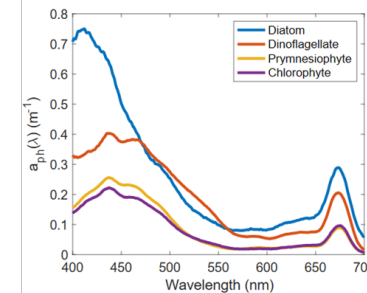


Decadal Phytoplankton Group Dynamics

- Nearly 20 years of cross-channel phytoplankton pigment biomarkers
- Shown are **diatom**, **dinoflagellate**, **prymnesiophyte**, **chlorophyte** & **picophytoplankton** groups
- Diatoms** dominate, vary seasonally modulated by climate variations
- Dinoflagellates** vary on decadal time scales due to advection of southern waters (supported by ROMS)
- Pico/nanos** show seasonal succession
- Partnership with Plumes & Blooms
NASA funded – just reupped for 3 more years!
PnB data hosted on SBC LTER database



Catlett et al. *Progress in Oceanography* [2021]



Blooms of different phytoplankton groups have different spectra (from Catlett and Siegel, 2018)
Seascapes are dominated by different phytoplankton (diatoms vs cyanobacteria).
Microscopy and pigments confirm different communities across seascapes. (Montes et al. 2020; Kavanaugh et al. 2014)

Integrating subsurface plankton distributions, higher trophic levels, connecting theory, and pipelines



In-situ Ichthyoplankton Imaging System (ISIIS): imaged taxa range from larger protists and phytoplankton to larval fish and gelatinous zooplankton.

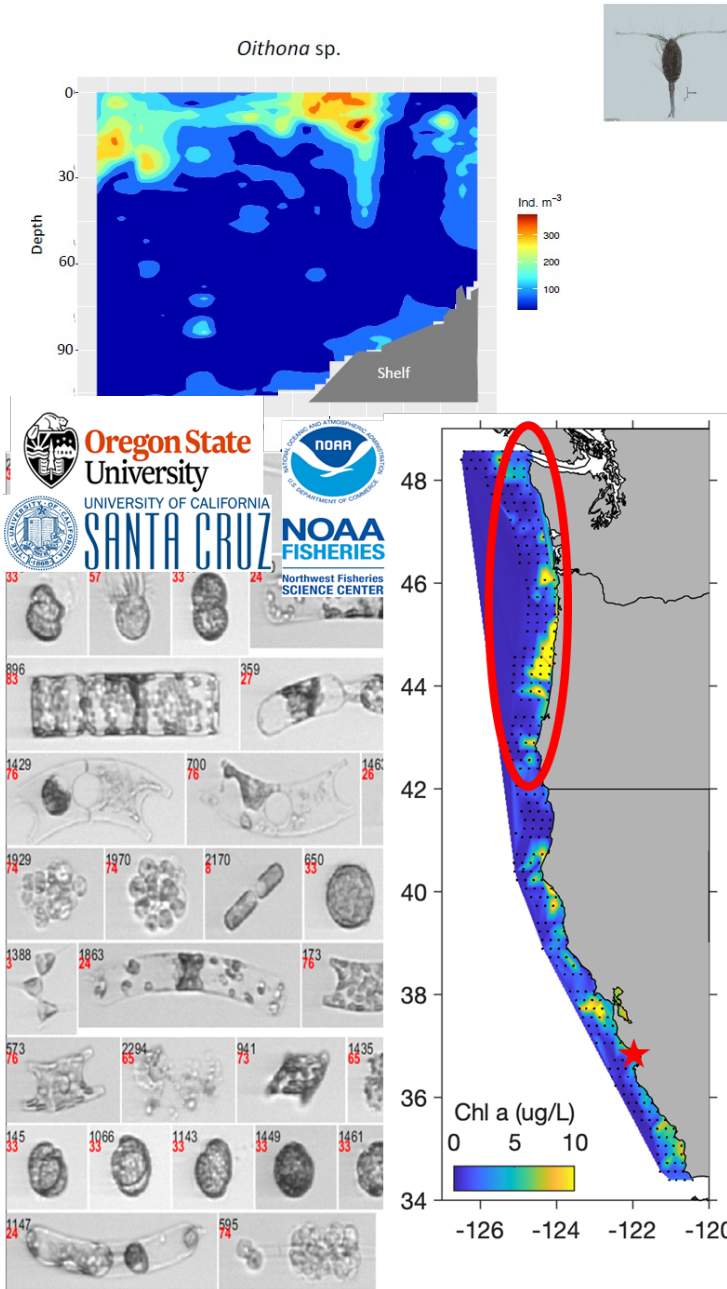
Schmid MS et al. 2021. A Convolutional Neural Network based high-throughput image classification pipeline <http://dx.doi.org/10.5281/zenodo.4641158>

- How do phytoplankton CS and PSD translate to zooplankton CS and PSD?
- How do subsurface plankton distributions correlate with their surface seascape?
- Is there a need to incorporate subsurface features into seascape classification?

Deliverable:

- Open access deep learning pipeline (Schmid et al. 2021). Developed for zooplankton images, but easily repurposed for other types of images (e.g., phytoplankton from IFCB, satellite imagery)

End Users: Sanctuaries, NWFSC, IEA
Owners: Cowen, Sponaugle, Schmid, Kavanaugh, Fischer, Moore

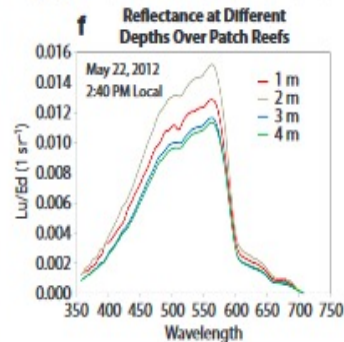
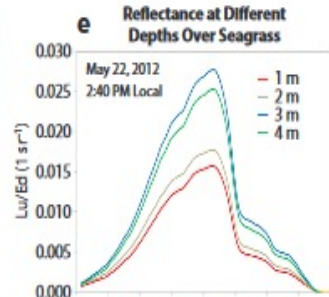
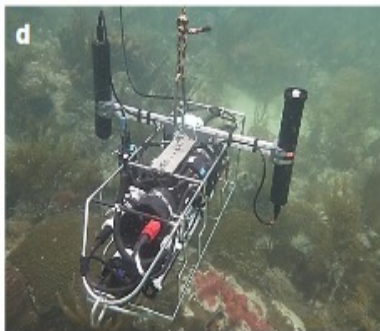
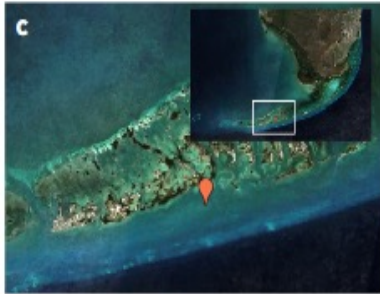
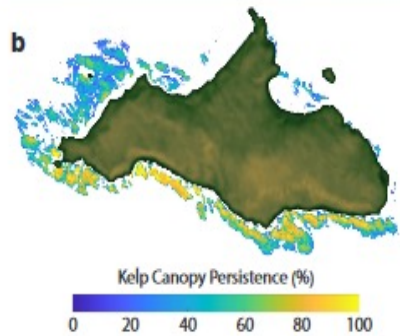
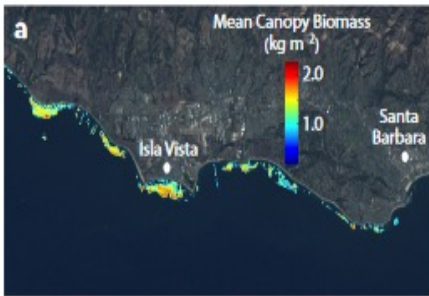


Foundation species provide habitat for entire communities

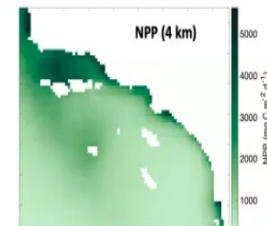
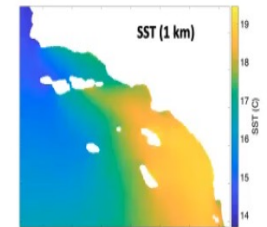
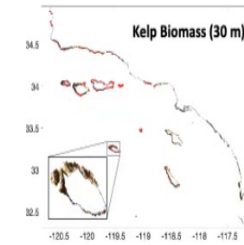
Abundances and Diversity of corals, seagrasses, and kelp
Landsat, Sentinel, and Rrs from in-situ optics

Owners: Bell, Siegel, Muller-Karger

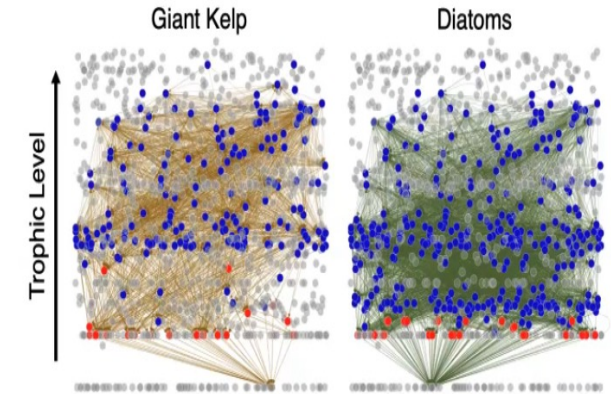
End-users: PACE, SBG Science and Applications



Remote Sensing Datasets



Topological Food Web



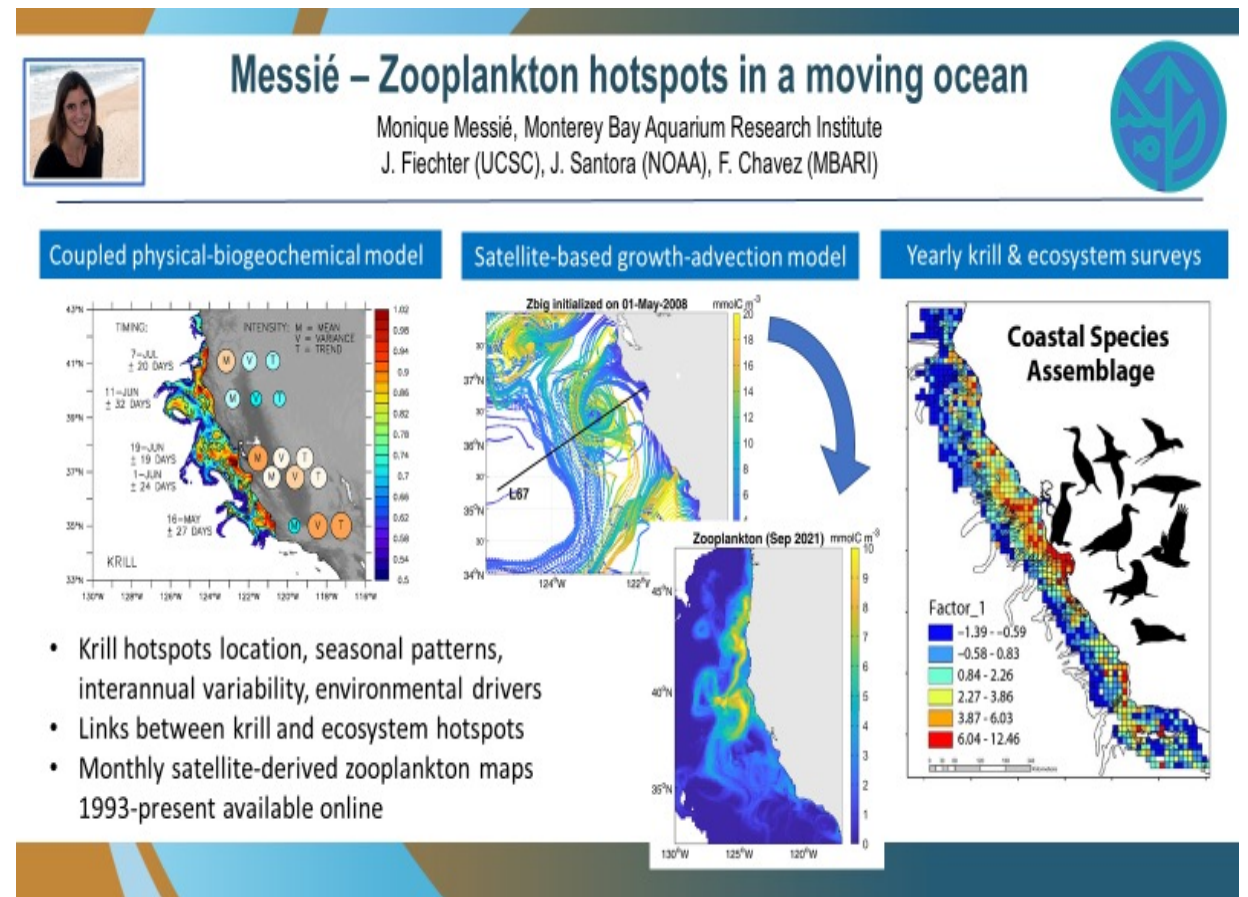
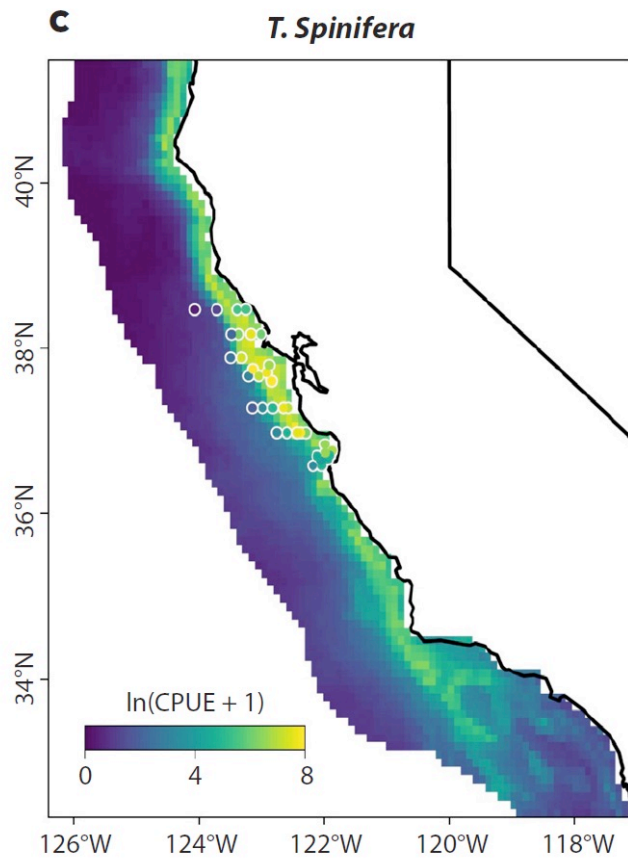
- Determine relationships between species abundance and primary production, biogenic structure & physical environment
- Use a novel food web to refine hypothesized community states and identify archetypical indicator species
- Predict and validate spatial patterns of rocky reef biodiversity across the Southern California Bight

Species distribution and Semi- analytical models

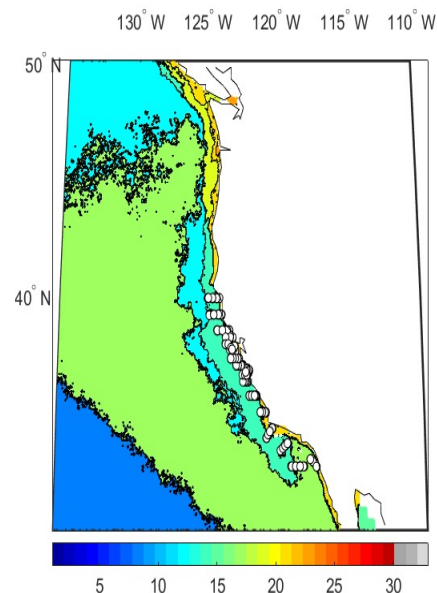
End-users: IEA, MBON

Owners: Cimino, Messié, Santora, Schroeder

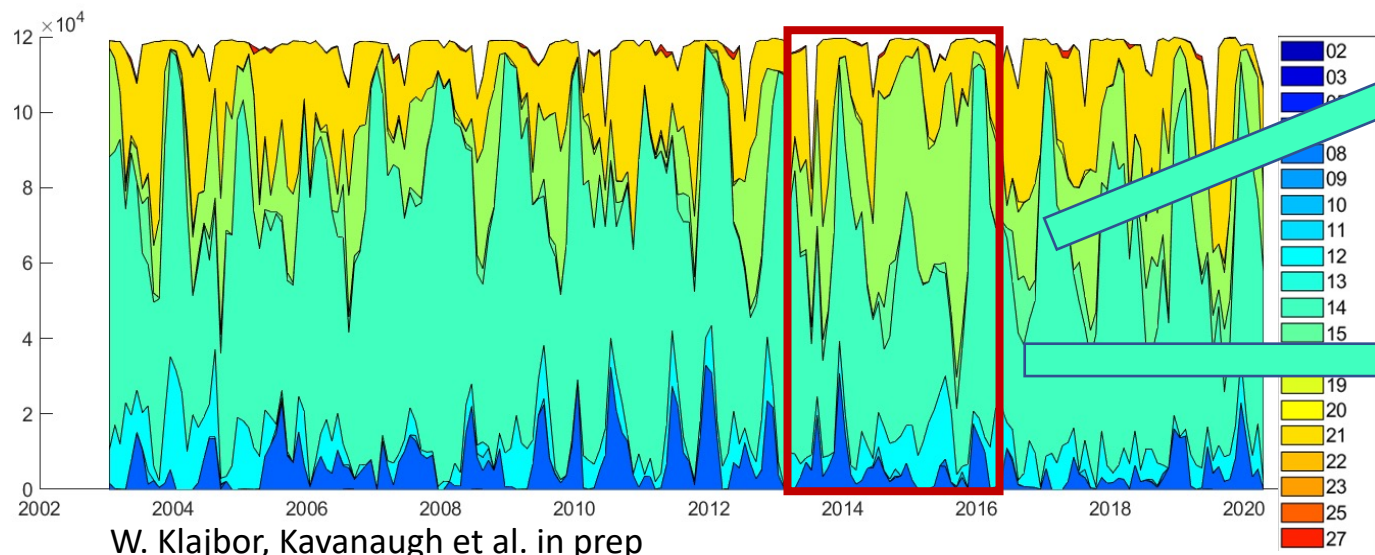
Next steps: incorporate more assemblage info, multi-species modeling



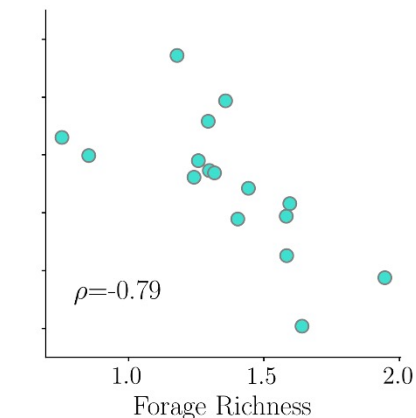
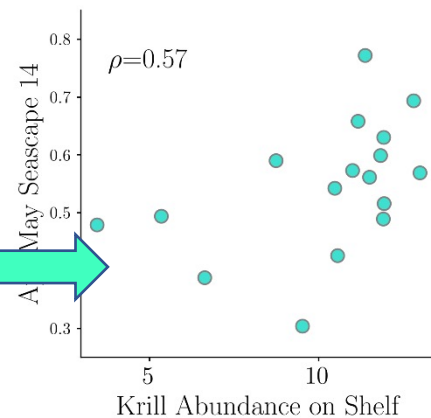
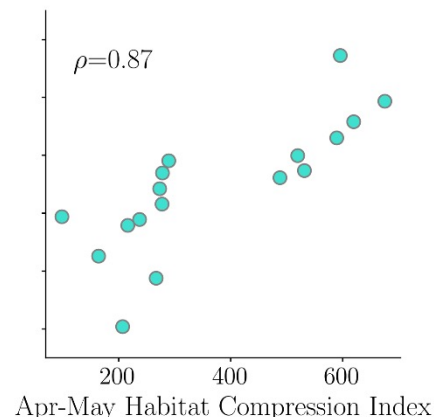
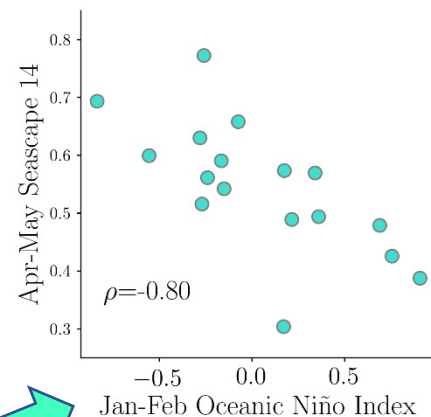
Effect of climate and events on habitats: Management relevance



Heatwaves and ENSO: productive seascape decreases extent and dominance
Decreases in krill,
increased warm water species,
compression of forage habitat,
increased conflict.



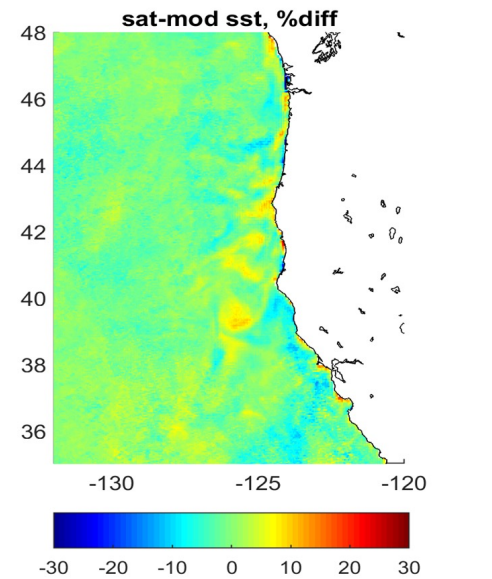
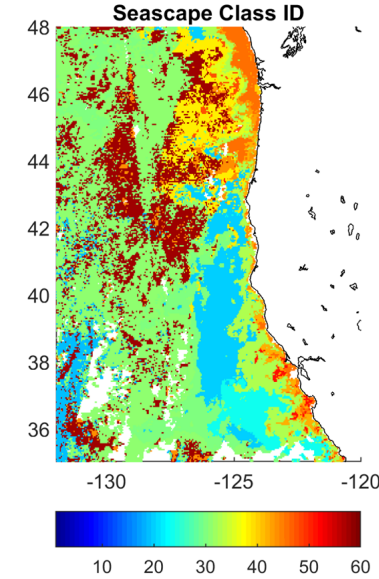
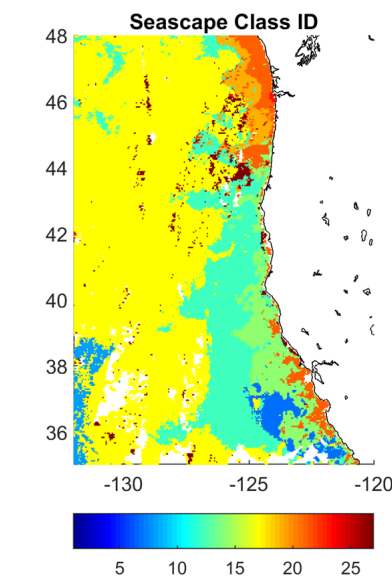
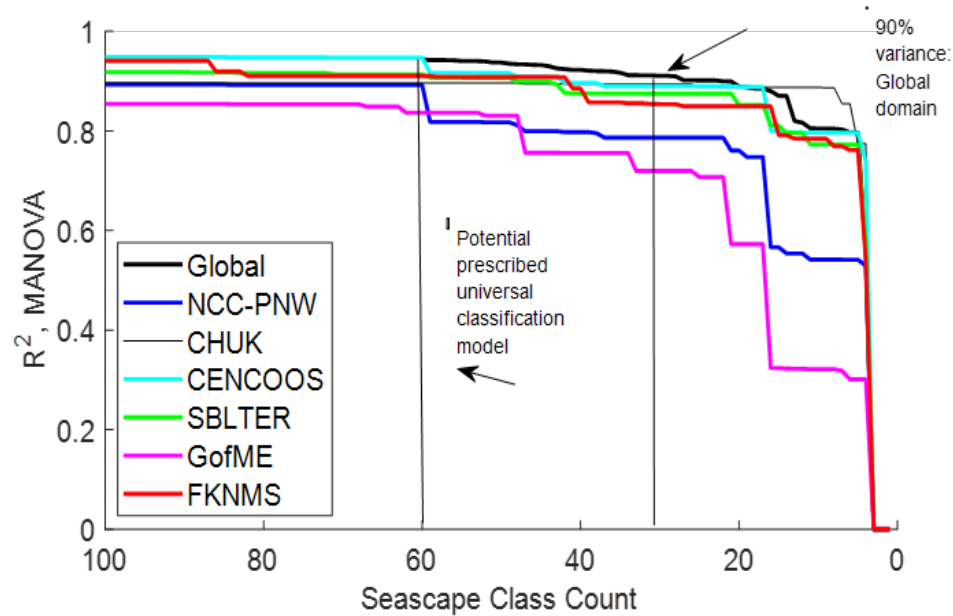
W. Klajbor, Kavanaugh et al. in prep



Santora et al., 2020 (Nature Comm), 2021 (Oceanography)

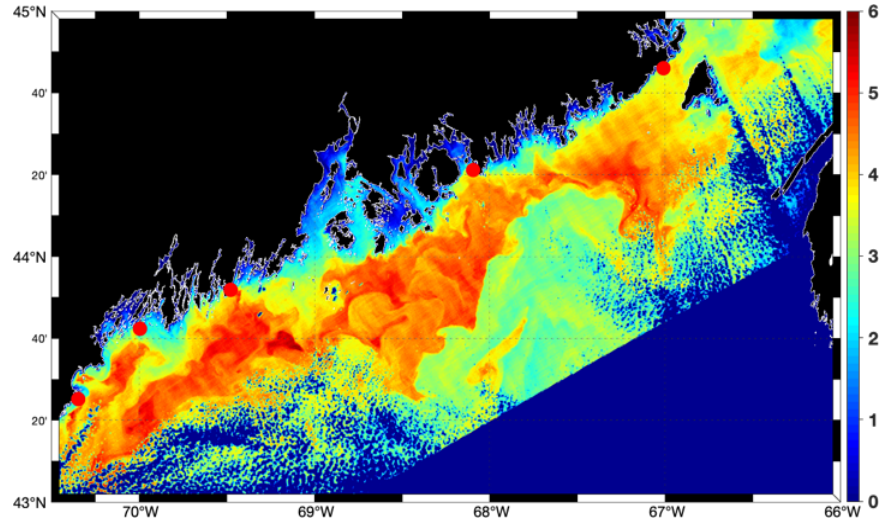
Downscaling next steps

Model solutions with increased classes to highlight regional variability are available for each MBON node. Training during next two XMBON working groups.



Continuity: CoastWatch MODIS to VIIRS in new Aqua Terra Suomi NPP award
End User: MBON Nodes, NMS, NOAA PMEL (OA program)

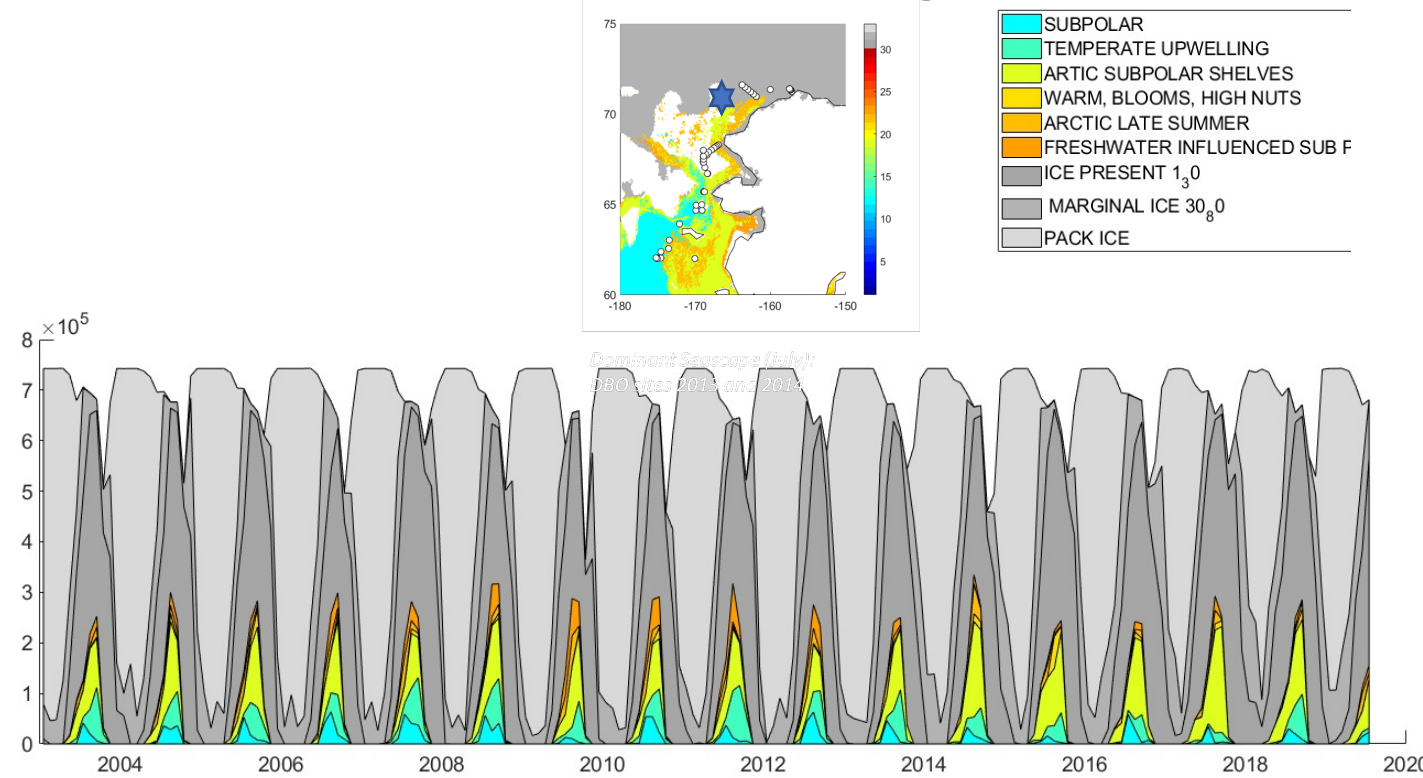
We continue to refine spatial scales, but we need to integrate additional remote sensing assets, strategic in water assets, and moorings



Higher resolution measurements will be key for observing change in coastal embayments

Owners: Otis

Areal extent (km²)

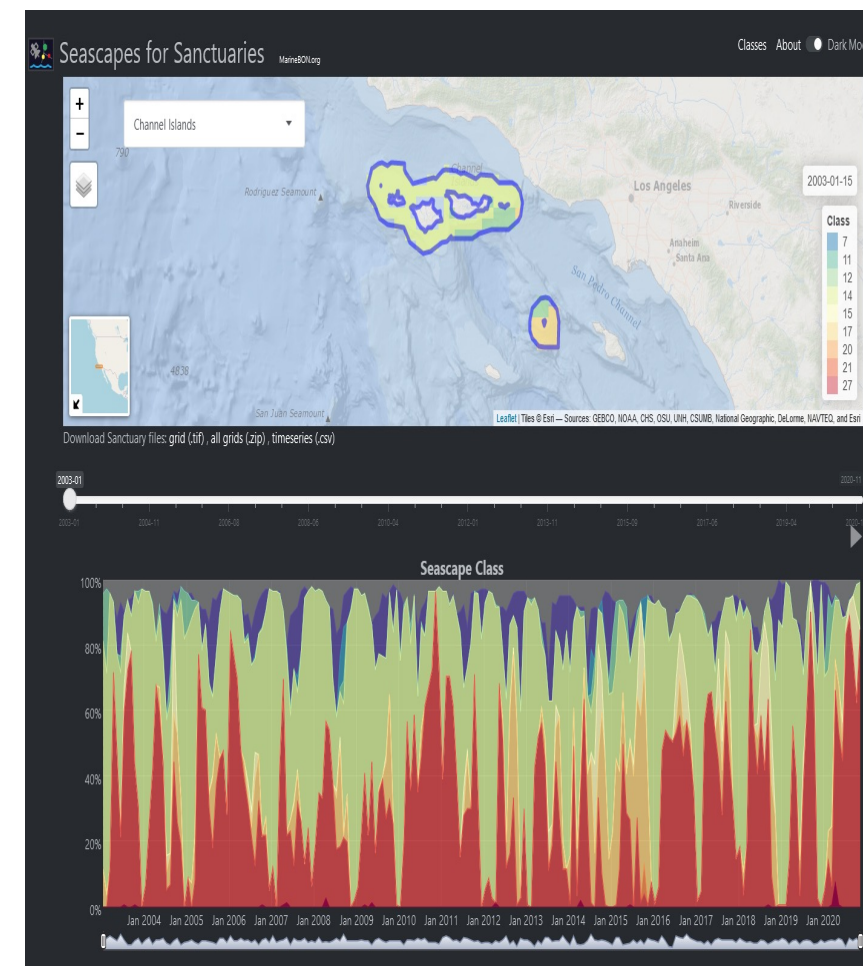
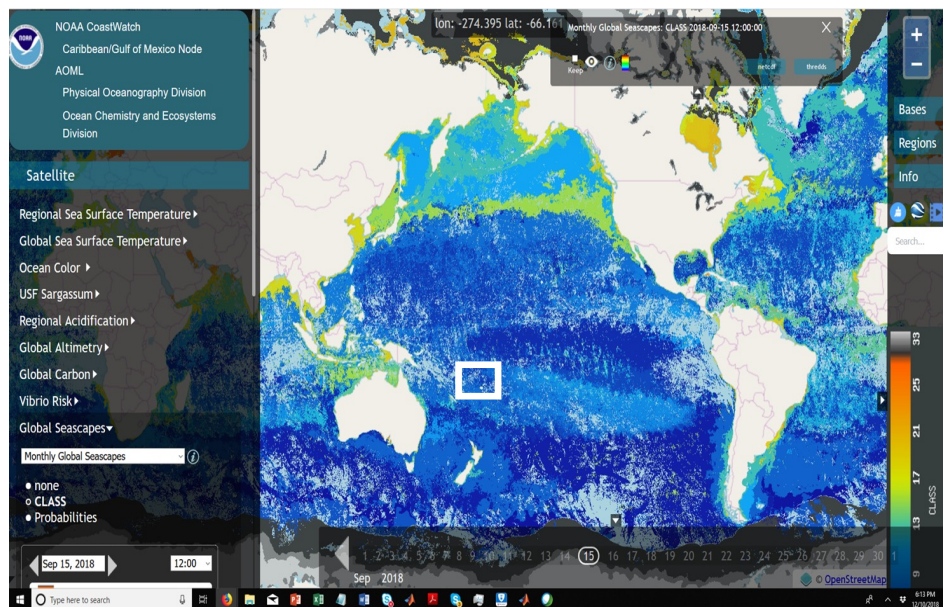
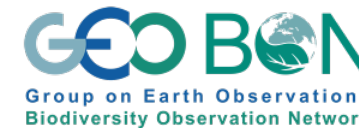


Seasonal and interannual variability in warmer seascapes from Pacific
Loss of pack ice (30-40%). ~~Increase cloud cover~~ (no ocean color,
below ice threshold). Solar angle insufficient during shoulder season
with increased open periods. CAN WE PLEASE GET LIDAR?? Necessity
for in water assets (e.g. CEO Mooring, Danielson).

Owners: Danielson, Grebmeier, Iken, and Kavanaugh

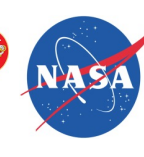
We're getting the products out there.....

- Global Seascapes are distributed through NOAA CoastWatch, R package, R-shiny
- High resolution products will be hosted by IOOS Ras (Dec-March): NANOOS MBON NCC, AOOS- AMBON, Somewhere in Florida



cwcgom.aoml.noaa.gov/cgom/OceanViewer/#
cwcgom.aoml.noaa.gov/thredds/SEASCAPE_MONTH.html
marinebon.org/seascapeR/
shiny.marinebon.app/seascapes

Owners: Trinanes, Best, Kavanaugh, Montes, Otis, Muller-Karger



Summary

- MBON remote sensing tracks: plankton groups, foundation species, higher trophic levels (SDMs) and pelagic habitat extent and diversity
- Remote sensing WG members integrates instrumentation (traditional and new technology), models, and ecological time series (context, mechanism, and partnerships). Provides validation, depth information, and increased taxonomic resolution.
- Indices used for marine ecosystem management: National Marine Sanctuaries, fisheries management, Integrated Ecosystem Assessment and global indicators EBVs and EOVs. PACE/SBG Application Readiness. Engage early, listen, and be ready for diverse needs.
- Indices also used for innovative science, and trans-sector science (e.g. academic-agency partnerships with IFCB). Science as stakeholders. How do we continue innovation and PACE/SBG preparation? Focused X-MBON studies across working groups?

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